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ABSTRACT

The following seven American programs of Computer Assisted Instruction in Medicine are among 20 implemented at the University of Bonn: OPHTHA and FUNDUS (programs of the tutorial mode), CARDI (presents information via three media on the clinical alterations of Mitral and Aortic Stenosis as well as Mitral and Aortal Incompetence), CARDIOPULMONARY RESUSCITATION (simulates patients with cardiac arrest and takes the students through the sequence of cardiopulmonary resuscitation techniques), ABDOMINAL PAIN and COMA (used over the Health Education Network), and CASE (Computer Aided Simulation of the clinical Encounter). These programs were evaluated by means of questionnaires or personal interviews. The results clearly indicate that students feel comfortable working with programs of the tutorial mode and that they regard them as being motivating and more efficient than traditional instruction. Furthermore there was a very favorable response to clinical simulation programs. (Author/VT)

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COMPUTER-ASSISTED INSTRUCTION IN MEDICINE:

A GERMAN VIEW

by

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

IR006237

Gunnar Voss, Jörg Weidenhammer, Hans E. Renschler

ABSTRACT - Some 20 American programs of Computer-Assisted Instruction in Medicine have been implemented at the University of Bonn, showing the problem of portability to be soluble. For a short time the Health Education Network was used, too. Seven programs were evaluated by the means of questionnaire or personal interview. The results clearly indicate that students feel comfortable working with programs of the tutorial mode and that they regard them as being motivating and more efficient than traditional instruction. Furthermore there was a very favorable response to clinical simulation programs.

1. INTRODUCTION

There have been two phases in the project to be reported here. During the first we studied the relevant literature (Weidenhammer 1976), established contact with many CAI groups in Canada and USA, and went on an intensive information collecting tour of some 20 of these CAI centers, to find out the current state of the art in Computer-Assisted Instruction in Medicine. The reason for having a relatively long phase of preparation was the very much delayed delivery of our hardware. When the terminals finally arrived there was less than one year left for implementing programs and gaining experience concerning their usefulness. This time was far too short for writing a number of programs as well as testing their instructional suitability. We are very grateful and indebted to the American CAI people, who gave us their programs and who, by their willing cooperation, enabled us to implement some 20 courses on the IBM 370/168 of our University Computer Center.

We had one typewriter, 3 CRT's, and one printer at our disposal, all supplied by IBM. We used standard FORTRAN IV and PL/1 of our Computer Center. In the FORTRAN language we implemented the physiological models MACMAN, MACPUF, MACPEE, and MACDOPE of the McMaster University, Hamilton, and a FORTRAN version of the Massachusetts General Hospital's (MGH) Cardiopulmonary Resuscitation Course also prepared at McMaster. In addition the access of other MGH programs was possible over the Health Education Network. For the cardiology course CARDI we implemented the language PILOT 73. To be able to use programs like OPHTHA, FUNDUS, and CASE we implemented Coursewriter III, where we had to expend a lot of time adapting it to our terminal configuration. - Seven of the programs used we tried to evaluate. These programs and our experiences with them will be described in the next sections.

Mr. Voss now is a member of the Project Group Computer Assisted Training (CAT) at the Fachhochschule für Technik , Esslingen; Mr. Weidenhammer is currently on his internship at the Marienhospital Euskirchen; Professor Renschler is Director of the Institut für Didaktik der Medizin der Universität Bonn. - This study was supported by the German Federal Department of Research and Technology.

As our contacts with the Clinic of Ophthalmiatrics were so good and because we found much interest and a highly cooperative attitude on the part of the Institute for Experimental Ophthalmiatrics we started our CAI venture with OPHTHA and FUNDUS. These Coursewriter III programs of the tutorial mode we receiven from the Ohio State University. Ophtha is accompanied by 37 and Fundus by 108 diapositives. Fundus has a simple question format. In the main part to each question there is only one right and one wrong answer. In the concluding section 26 slides showing different eyegrounds are displayed again and the student has to enter in natural language what is shown. Ophtha has a more varied question format: right/wrong, multiple-choice, matching items, open questions to be answered in natural language. The Ophtha diapositives are not of the best quality, while Fundus uses extremely good ones.

The programs teach the fundamentals one has to know to give a correct interpretation while examining the fundus of the eye. With the application of these programs we had a specific hypothesis in mind with respect to their possible instructional function. We knew that many students find it difficult to interpret what they see using the ophthalmoscope, because they lack the relevant knowledge to be able to correctly assess observations of the eyeground. We felt that the CAI courses would be helpful in meeting this need. In this way students should later be in a better position, in their bed-side-teaching to assess their observations.

Much work was put into the adaptation of 4 lessons of Dr. R.E. Rossall's Coursewriter II Cardiology Program, developed at the University of Alberta, Edmonton. This work was done by our colleague Dr. G. Schilling, who named his version CARDI. CARDI presents via three media (CRT, slide projector, tape recorder) information on the clinical alterations of Mitral and Aortic Stenosis as well as Mitral and Aortic Incompetence. While in the original program (implemented on a IBM 15oo) the audio and the visual information is controlled by the CPU, our students had to operate the slide projector and the tape recorder on their own, because we did not succeed in constructing the needed interface on the hardware level. As we were unable to use Coursewriter II (there are no IBM 15oo computers in Germany) we had to rewrite the program, for which we took the language PILOT 73, which we received from Starkweather and Kamp.

All this adaptation took us about 100 hours working time for one hour user time (the students on average needed 6 hours for all 4 lessons). In addition the course was pretested with 49 students and revised thereafter. The figure of 100 hours working time is in line with the amount of time needed by Dr. d'Ivernois of the University Laval, Quebec, who also adapted this course. According to him about 50 % of working time is saved by adapting a course instead of constructing a new one.

From McMaster University we received a FORTRAN version of CARDIOPULMONARY RESUSCITATION, a program developed by Massachusetts General Hospital. The program simulates patients with cardiac arrest - the version used by us included 7 cases - and takes the student through

the sequence of cardiopulmonary resuscitation techniques. All this is done in a step-wise fashion taking advantage of the simple multiple-choice format. At each step the patient's reaction is described and the student has to make a decision about what to do next. Then the patient again reacts to the measure taken and the student has to choose his next decision.

Other MGH programs, mainly ABDOMINAL PAIN and COMA, we used over the Health Education Network. For this purpose we had to rent a Silent 700 terminal with an acoustic coupler. Our entry point to TYMNET was Brussels.

COMA is designed to teach how to evaluate a comatose patient as such patients present to the emergency department. Thirtyeight causes of coma are considered, including both primary neurologic disorders and toxic-metabolic conditions.

After being given a brief initial history, the student must evaluate the "patient" by asking for further history, physical findings and laboratory test data, using numbers from the accompanying vocabulary. This can be done in any sequence, though the computer will refuse requests that are not reasonable. The answers to history and physical exam items will be given immediately, while the results of laboratory tests will be given after a time delay reflecting the real world time required for the test. If the student is unable to proceed without one or more test results, he may push the computer's clock forward by typing "Time" in order to receive these results at once. A variety of assistance is available, if one types the word "HELP". The student may review the data gathered, find a test's normal value, get information about any item in the vocabulary, our get advice on how to further work up the "patient".

In ABDOMINAL PAIN the student is given a short description of a patient with a chief complaint of abdominal pain. The patient may have any one of 33 different causes of acute abdominal pain. Again the student has available an index of history, physical exam and laboratory data items about which he can obtain information.

At any time, the student may type the word "HELP" to request the computer to interpret information gathered to that point, criticize the student's last action, and suggest the most useful tests to perform next. At any time, too, the student may decide that he has sufficient information to terminate the dialogue and make a final diagnosis. In entering his diagnosis, the student types the name of the disease rather than a number from a vocabulary list. There is a powerful free text recognition program which allows the computer to recognize almost any plausible diagnostic term that is chosen by the student.

We also implemented the very well known CASE system (Computer Aided Simulation of the clinical Encounter) developed at the University of Illinois. The special thing about this Coursewriter III program is a dialogue pattern that from beginning to the end is in natural language. The student again is asked to take a history and to get the relevant physical exam an laboratory data. When he has completed the dialogue he receives a description of the diagnosis

and a sample treatment plan suggested by the author of the case, as well as a list of the critical concepts which the author considered important in identifying and managing this particular disease situation. With each critical concept there is an indication wether the student asked for this information.

As German interns are not perfectly fluent in English Medical Terminology, we prepared a glossary of important terms which they were allowed to use during their interaction with the simulation. For the purpose of evaluation we have used the cases John Franklin, Esther McGrory, James Bond, Richard Lemis, Bonnie Clyde, George Thompson, Horst Schultz and Nicole Laurens. After working through some of these cases there was a structured group discussion of three interns at a time.

The students who have seen the courses OPHTHA, ABDOMINAL PAIN, and COMA were interviewed while those taking FUNDUS, CARDIOPULMONARY RESUSCITATION, and CARDI answered a questionnaire. The items used for the CARDI questionnaire were adapted from the Student Opinion Survey (SOS) by kind permission of the Computer Assisted Instruction Laboratory of the Pennsylvania State University. This allowed us to compare the reaction shown by American and by German students to CAI.

3. FINDINGS

60 students in their second clinical year used the tutorial programs OPHTHA or FUNDUS in conection with heir regular instruction (lecture and bed-side-teaching) in Ophthalmiatrics. Participation took place on a voluntary basis. The programs used were in English language.

The average time spent on FUNDUS was 3 hours and 55 minutes, most students choosing 2 to 3 sessions. The average time spent on OPHTHA was only one and a half hours, because most students chose a shortened version we had specifically prepared for this purpose. The students taking OPHTHA were interviewed while students who had used FUNDUS answered a questionnaire.

The rating of the effectiveness of these courses was positive, since half of the students believe that they learn more using the computer than studying a good textbook and 85 % regard this method of instruction to be more efficient than the usual lecture. This does not mean that they want to abolish the lecture completely. Some students like the personal way of teaching; they feel it to be more vivid; they appreciate the opportunity to ask questions and the social atmosphere as a whole. What students want is fewer and better lectures combined with more bed-side-teaching. And as a third component they would like computer programs, for two thirds are clearly convinced that the inclusion of CAI would improve teaching in Ophthalmiatrics, and the other third thinks it is possibly good. Very favorable views were also expressed by four professors of Ophthalmiatrics, who thoroughly checked the two courses, which took them 2 to 3 hours for each program. If there should exist

enough such programs - in the German language - they think that a combination of one fifth CAI, two fifths lectures, and two fifths bed-side-teaching would be a good mixture.

Why do students like CAI? - The three main reported reasons are:

- In order to answer the questions you have to be active and you have to concentrate on the material shown.
- It is fun to have feedback to the answers given.
- You can work at your own pace; you may come and go when you like.

For which instructional goals are courses of this kind thought to be suitable?
The leading three alternatives have been (each chosen by some two thirds of the students):

- To get an overview and first impression, before one is going to have bed-side-teaching.
- To learn in more depth such subject matter one already is acquainted with.
- For self-evaluation purposes.

The first alternative concurs with a hypothesis we had before application of the programs (s. page 2).

53 students, most of them in their first clinical year, took, as a complement to a programmed course on heart auscultation, the multimedia cardiology course CARDI, where they spent on average 6 hours on the 4 adapted CAI lessons. Again the rating of the effectiveness of the tutorial CAI mode was positive:

86 % were satisfied with what they learned while taking the course.
82 % feel that CAI, as used in this course, is an efficient use of the student's time.
75 % think that CAI makes it possible to learn quickly.
73 % believe that, in view of the amount they learned, this method seems superior to traditional instruction.

One of the most important parts of the tutorial interaction process is the adequacy of feedback responses the student receives to each answer he enters. With respect to this feature the cardiology course seems to be of good quality, since 82 % judge the responses to their answers to be adequate. And there is a large majority saying that the encouragement from the feedback received is very helpful for their learning.

As the tutorial teaching mode is said to simulate the personal interaction between a tutor and a pupil, it is interesting to know, whether programs of this kind are in fact flexible enough to create such a personal atmosphere. Only 44 % of our students claim to feel as if they had a private tutor; the majority of 56 % does not perceive it this way. Also there is a significant group of 42 % that found the computer-based learning not to be flexible enough.

The limited flexibility, however, seems to be experienced as a minor disadvantage, because it wasn't found that the students felt uncomfortable about CAI. On the contrary, they did not feel frustrated by the learning situation (96 %); they did not find this way of learning to be too mechanical (79 %), and they did not expect material which is otherwise interesting to become boring presented by the computer (87 %).

That the course is motivating is shown by the following results: the students felt challenged to do their best work (83 %), the program has contributed to the development of positive attitudes towards the course material (74 %), and as a result of having studied by this method, the students are interested in learning more about the subject matter (91 %). - Finally a very important point is the fact that CAI allows the student to work at his own pace. All participants agree that this is a very favorable condition for learning.

Let us now turn to the clinical simulation programs beginning with CARDIOPULMONARY RESUSCITATION of the Massachusetts General Hospital, which we used in a version prepared at McMaster University. This course is constructed in the multiple-choice format and therefore akin to CAI of the tutorial type. 25 students, most of them in their second clinical year, and 10 interns, worked up 4.6 cases on average for which they needed 80 minutes. Again Computer-based Instruction is rated as an efficient use of students' time (90 % agree). Two thirds believe that you learn more by using the computer than by studying a good textbook. According to 80 % the subject matter is taught in a way that cannot be imitated by traditional methods, such as lecture and books.

Two thirds felt the program to be realistic and for this reason felt challenged to do their best. Half of the students during the program had the impression of being confronted with an authentic case. On the other hand, a fifth of those questioned found the CAI not to be flexible enough and another third felt uncertain on this point. One third also found the multiple-choice format restricting.

There was 90 % agreement that practical training combined with computer programs is more efficient in teaching resuscitation techniques than practical training by itself. When asked for the best combination of media in training resuscitation, practical exercises and computer programs were mentioned most often (by approx. 90 %). They were followed by textbook (60 %) and film (50 %). About a third also included lectures and last of all came the slide-tape show. The main reasons for prefering computer programs are the active involvement of the student, the immediate feedback, the use of the case method, and the enforced decision making reflecting the real world situation. And again it is seen as a very favorable condition that the student may work at his own pace.

Also six anesthesiologists have examined all cases of this program. Their opinions are similar to those of the students and interns. They also find the program realistic and extremely suitable for training purposes.

We now proceed to the other type of MGH clinical simulation program, where the patient is represented by a static model for which the computer has a file of information, which the student can get by using a vocabulary. 10 interns and 8 physicians used this type of program, mainly ABDOMINAL PAIN and COMA. Altogether they have worked up 57 cases of Abdominal Pain, 55 cases of Coma, and 22 cases of other programs (Diabetic Ketoacidosis, Hypertension Diagnosis, Jaundice, Joint Pain, Trauma). On the average the interns saw 9.3 cases, for which they needed 4 and a half hours, and the physicians have worked up 5.1 cases which took them 2 hours and 40 minutes on the average.

12 other interns used the CASE system. On an average 3.5 cases were seen by each intern - altogether 42 cases. It took 50 minutes to complete one case. By comparison, only 30 minutes were needed for one case of the MGH vocabulary type programs.

The 22 interns and 8 physicians who altogether saw 176 cases (COMA, ABDOMINAL PAIN, CASE) were asked to comment on 6 claims in favor of the use of computer simulated patients. There is perfect agreement on the two following claims and a little less agreement about the third one: (1) Experienced clinical teachers with sufficient time are rarely found. (2) Artificial patients can be represented completely (beginning with the first contact and continuing until final diagnosis and therapy decision). Several restrictions that characterize the real world situation do not apply, e.g. the clinical schedule, limited time for examination of the patient etc. (3) Contrary to the real world situation the student can make mistakes without taking risks and learn from these mistakes.

About the claim: "The students cannot be provided with exposture to all important clinical problems; computer programs can be constructed in an unlimited number and are available at any time", there is a basic agreement, but several times the point was made that the computer nevertheless has its limits: it's not possible to represent everything this way, e.g. dermatoses. The computer is not really adequate in delivering information that in real life is gotten by eye, ear, smell, and by palpation.

Feelings are mixed concerning the claim "Bed-side-teaching normally takes place in a more informal and not very systematic fashion. Computer programs allow the possibility of more systematicly training the diagnostic decision making". Half of those questioned do not agree with the first part of this claim. They think their bed-side-teaching is quite systematic, even if it varies from teacher to teacher. One intern also said that small group bed-side-teaching, as customary in England, clearly would be superior to computer programs, and that real patients could be asked in a more flexible way.

One of the six claims was unanimously rejected: "An instructor, especially a good one, can be too good a diagnostician. He is so quick in his decisions and takes into account such complex circumstances, that the student cannot follow". This does not seem to describe the typical situation in Germany. The clinical instructor usually presents patients whose case histories are known to him and so he can unfold the case from "inside". The students said that there were certainly those who were quick to diagnose, but who would modify

their teaching methods to suit the needs of the students; if this were not the case, it would be up to the students to interrupt with questions.

The interns and physicians, who have worked through the Boston programs, have answered some additional questions. All believe that a student learns more using the computer than studying a good textbook. They give as the main reason that the book always begins with a description of the clinical problem. The symptoms and data follow later. In the programs as in real life it is the other way round: at first you get the data and from there you have to go on. This sequence is supposed to leave a deeper impression, to ask for more participation and above all it is analytical.

All are fully convinced that in order to teach diagnosis (and therapy) of outpatients and acute cases a combination of lecture, computer programs and practical exercises is more appropriate than lecture and practical exercises by themselves. It is true, however, that half of the physicians stress the fact that a good instructor - if available - is better than the best program. One M.D. suggests that success in practical training depends on the size of the group of the students. With a group of not more than six persons (as in England) computer programs could never compete with a good instructor who gives his attention to each one of his students. If there were an adequate number of clinical teachers and patients available, computer programs would be redundant. By contrast, under German conditions (the groups being large) a combination of teaching aids including computer programs would certainly be superior.

The next question was about how much time should be spent on clinical simulation programs during internship. To this question the following average figures were given:

- by the interns 5.3 hours per week
- by the doctors 4.5 hours per week.

To a similar question the CASE-group suggested 3.5 hours per week. These figures presuppose that the practical training is not reduced.

The interns feel that the appropriate stage for introducing these programs is the second clinical year. According to the physicians one should wait until the 3. clinical year and the program COMA, for example, they would even postpone until internship because of its difficulty. If there were several versions of the computer programs at different levels, they could be used in all phases of clinical education. In their present form the programs were also thought to be suitable for refresher courses in continuing medical education.

It is not intended that these programs should only be used as enrichment on a voluntary basis. The interns feel they could very well be an integrated part of the curriculum. Of course, then there should be an explicit coordination with lectures and bed-side-teaching. The interns see the main benefit derived from this kind of learning in an improvement of their differential diagnostic abilities, something that is felt to be lacking in the present method of instruction. The physicians expect from clinical simulation programs that the

diagnostic process will be carried out in a more conscious fashion and that the student will be taught a more methodical and economical diagnostic procedure.

4. COMMENT ON EVALUATION

As everyone having to do in some way with Educational Research certainly is aware there exists the very tricky problem of how to adequately evaluate instructional systems. What we have done in this respect is on a modest scale, of course. But we were forced to continually reassess this problem. Therefore we feel this deserves some mention here.

We had promised to the federal institution, from which we received the grant, that we would do experimental evaluation studies, and provided there had been sufficient time, those studies would have been carried out. However, while visiting CAI groups in the United States we also met colleagues of the well-known Center for Instructional Research and Curriculum Evaluation at the University of Illinois, Urbana-Champaign, who warned us against doing such simple outcome studies and instead, suggested investigating how students perceive CAI. One problem, they argued, is that as CAI allows the students to work at their own pace the better students will proceed faster; in traditional lecturing this does not apply and therefore on the average the CAI group has the chance to learn more effectively. As our reported results show very clearly that one of the main advantages of CAI as seen by the students is, indeed, the opportunity to learn at one's own pace, we can only agree to the possible importance of this argument.

At any rate we very early gave up the idea of comparing CAI with lectures, because normally in studies of this kind at least two difficulties are involved. In the first place, the investigator is dependent on the teaching ability of the chosen lecturer and, secondly, it is difficult to insure that exactly the same subject matter is treated. That this insufficient control, in fact, may be the reason for invalidating experimental results, we learned for instance at the Institute of Cardiology of the University Laval, Quebec, where a significant difference between lecturing and the CAI Cardiology Course was found (d'Ivernois et al., 1975).

We ourselves therefore would have preferred to produce a completely congruent audiovisual version and to experimentally compare it with the CAI Cardiology Course (we began to do so but because of insufficient time were not able to complete it). Against this type of study, however, the argument still applies, that it is impossible to prove the general superiority of anyone medium by just comparing single courses only, for there might be simply a difference in quality between the programs one has chosen. If one is unable to do many experiments to check a whole range of different course materials, it is possibly preferable to follow the suggestion of the instructional researchers of the University of Illinois, in other words to merely assess how students perceive the characteristics of CAI, as we in the end did.

Admittedly one disadvantage of the design chosen for our study is that there are no precise rules for generalizing the results

obtained. Even assuming that our findings were based on representative samples, what would such findings as that our students claim to experience CAI as motivating and as more efficient than traditional teaching actually mean? Is it mere novelty (Hawthorne effect)? Does CAI just stand out compared to an otherwise low standard of teaching? What part of the effect is due to the good quality of the slides accompanying the CAI course or other peripheral features? Without experimental control there is necessarily a great scope for ambiguity. - On the other hand, there is one favorable indication speaking for the validity of our findings. Our using an American Opinion Survey made it possible to compare the reactions of German and American students working with CAI courses of the multimedia tutorial mode, where only the course material differed. Among 18 items that could be compared there was only one showing a difference in attitude, while the responses given to all other items were very similar (Schilling & Voss, 1977). This seems to indicate that our findings might be quite substantial instead of being rather ambiguous.

5. CONCLUSIONS

CAI programs of the tutorial mode seem to be characterized by a combination of such distinctive advantages that even the problem of insufficient flexibility does not bother the students. The main advantages are that the student is actively involved in the learning process, that he is encouraged by immediate feedback, and that he is allowed to work at his own pace.

Clinical simulation programs are also seen as superior to traditional teaching methods, which is not so surprising as they are, in fact, a medium with which no other medium can compete. The only possible competitor for systematic training in clinical problem solving would be the experienced clinical teacher in the small group situation. Unfortunately such teachers, that is those, who have sufficient time, are rarely to be found, if not nonexistent. But even if we had them, it might very well be that programs of this kind could contribute specific aspects of their own towards building up an economic and efficient diagnostic decision making. Consequently it would seem that a well balanced mixture of lecture, bed-side-teaching and simulation programs (the latter for about 4 to 5 hours per week, as the persons questioned suggested) would be an ideal combination.

If there are by far too few teachers, as in Germany, there exists the danger of conceiving of computer "patients" as viable substitutes for bed-side-teaching. This certainly would not be approved by our interns and students.

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